# COLLECTIVE EXCITATIONS INDUCED BY PAIRING ANTI-HALO EFFECT

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Soft vibrational excitations in neutron drip line nuclei are one of the most interesting issues in nuclear structure physics. Naively we expect soft excitations associated with neutron skin, halo degree of freedom. A famous one is soft dipole mode. However it is a fundamental question whether such collective modes really appear or not.

Vibrational excitations are represented as coherent superposition of one particle - one hole (1p-1h) states. In stable nuclei, 1p-1h states between tightly bound states only contribute, and these 1p-1h states localize spatially around the nuclear surface. Around neutron drip line, by contrast, 1p-1h states between tightly, loosely bound, resonance, non resonant continuum states, are contribute. Because each 1p-1h state has different spatial characters, appearance of vibrational modes, as a result of coherency between such 1p-1h states, are non-trivial.

We discuss that selfconsistency of pairing correlations in Hartree-Fock-Bogoliubov (HFB) theory plays important roles to realize collective excitations around neutron drip line. In Hartree-Fock (HF) and HF plus BCS (non-selfconsistent pairing) calculations, hole wave functions have the asymptotic form, $\varphi_i\left(\varepsilon_i, r\right) \rightarrow \exp\left(-\alpha_i r\right)$ with $\alpha_i = \sqrt{-2m\varepsilon_i}/\hbar$. As the single-particle energy $\varepsilon_i \rightarrow 0$, $\alpha_i$ approaches zero, and the wave function has large spatial extent. In HFB, by contrast, hole wave functions have the asymptotic form, $v_i\left(E_{qp}, r\right) \rightarrow \exp\left(-\beta r\right)$ with $\beta = \sqrt{2m\left(E_{qp} - \lambda\right)}/\hbar$. This $\beta$ is finite with pairing gap $\Delta$, namely, as the Fermi energy $\lambda \rightarrow 0$, $\beta \rightarrow \sqrt{2m\Delta}/\hbar$. This localization of wave functions is called as "pairing anti-halo effect" [1].

We performed Skyrme-HFB plus selfconsistent quasiparticle random phase approximation (QRPA) calculations [2] for low-lying first $2^+$ states in neutron rich Ni isotopes. We show how pairing anti-halo effect plays important roles to realize soft vibrational excitations in neutron drip line nuclei.

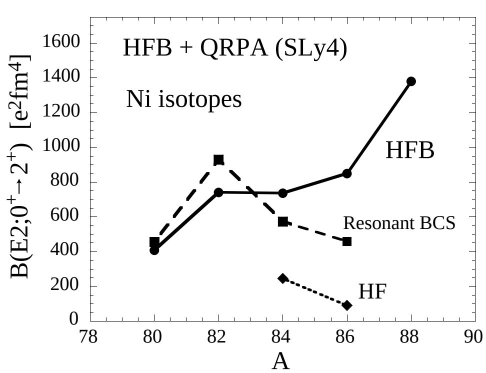


Figure 1: The $B(E2, 0_1^+ \rightarrow 2_1^+)$ values in Ni isotopes by HFB plus QRPA, resonant BCS plus QRPA (without anti-halo effect), and HF plus RPA calculations are shown.

[1] K. Bennaceur, J. Dobaczewski, and M. Ploszajczak, Phys. Lett. B **496**, 154 (2000).
[2] M. Yamagami and Nguyen Van Giai, Phys. Rev. C **69**, 034301 (2004).